Geoarchaeology and Archaeomineralogy (Eds. R. I. Kostov, B. Gaydarska, M. Gurova). 2008.
Proceedings of the International Conference, 29-30 October 2008 Sofia, Publishing House "St. Ivan Rilski", Sofia, 358-361.

A NEW ROCK FEATURE – CRYPTIC STRUCTURE (FRUSTUMATION): POSSIBLE IMPLICATIONS FOR CONSERVATION AND PRESERVATION OF ROCK-MADE ARTEFACTS

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ABSTRACT. It was shown that the primary element of the object-system "rock as essentially natural mineral paragenesis" one should consider not only a mineral grain (even for the monomineral rock), but some primary mineral grain aggregate or ensemble in the Ilya Prigogine`s sense. It was predicted that such natural phenomenon (named "frustumation" from *frustum* – lump, in Latin) should be revealed with various spectroscopic methods of rocks treating (Povarennykh, 1989). In several genetically different rocks (varying from sedimentary halites, metamorphic marbles, metasomatic skarn to magmatic granites, carbonatite, liparite and pegmatite) frustums were discovered and revealed with the help of UV-irradiation (of 254 nm wave length) and laser-ultrasonic echoscopy (Povarennykh, 2006; Povarennykh, Beskin, 2006; Povarennykh, Rassulov, Lobzova, 2006; Povarennykh, 2008). Preconditions of this rock cryptic structural phenomenon discovery are contained in the works of S.M.Beskin (1979; 1981), A.G.Zhabin (1971; 1975; 1979), I.S.Delitsyn (1985; 1990), V.V.Indutny (1982; 1991), A.N.Nikitin (1996), O.A.Sustavov (2005), and M.Yu.Povarennykh (1989, 2000), and much before in the works of F.Levinson-Lessing (1936) and E.S.Fiodorov (1896) on the essential significance of macrophysiographical (supertextural) rock characteristics. In order to reveal the petrophysical essence of the rock primary lumpiness (frustumation), complex of different scale investigations were conducted (from nano- to decimeter levels) of magmatic, metamorphic and sedimentary rocks with simple mineral composition and genesis with the help of traditional mineralogical-petrographical methods (optical microscopy, XRD-and microprobe analyses) as well as rock thermal resistance determination method, laser-ultrasonic spectroscopy and UV-luminescence. Features of this firstly discovered macroscopic stereological rock phenomenon and its possible implications to conservation and preservation of rock-made artefacts as well as to rock crushing and ore dressing are discussed.

Introduction

The appearance of automatic image analyzers, autogoniometers, R-microtomographers and neutronographic structure spectrometers rapidly increased the interest in the rock stereology. In consideration have to be also modern synergetic ideas combined with the mathematical apparatus of the graph and fractal clusters theories. However, numerous attempts to apply the formal-symmetrical approach to the rock stereology investigation have failed to produce important achievements in theoretic-petrographical sense. The same was the fate of the opinion that the mineral grain ought to be the unique genuine rock-system primary element.

While defining rock, petrographers usually are limited by the description of microstructure, microscopic diagnose of mineral constituent of rock, and its overall chemical composition. It is well known, that such *different* rocks as granite, arkose sandstone and gneiss may have *equal* overall chemical composition.

Except the above mentioned rock properties, we have an opinion for the essential importance of macrostructural rock characteristics. F. Levinson-Lessing has noticed in the 1940s: "Macrophysiography is as old as the rock geology itself. Skilful usage of macrophysiography by our predecessors in premicroscopic era in many cases is much more successful in comparison with us constantly interested in microscope and chemical analysis and often neglecting macrophysiography".

From the modern investigators, S. M. Beskin has most clearly underlined the significance of this rock parameter (macrophysiography) in his works devoted to the rare-metal granite nomenclature. For these widespread rock types, he suggested to imply "…quartz and feldspar crystal grains (without detailed elaboration of the latter in its composition) distribution peculiarities within the rock groundmass". As a result of such an approach (jointly with V. N. Larin and Yu. B. Marin) prolonged geological investigations and mapping of the Late Proterozoic and Phanerozoic former USSR granite massifs it was established that natural granite associations could be revealed in the first place by their groundmass macrophysiography (without taking into account the porphyry phenocrysts) and that there were three (А-, Б- and В-) general physiographic granite types which could be correlated with different ore deposits. "A-type is unequally-grained granite with random distribution of quartz and feldspar grains as well as with a low degree of aggregativeness of the mineral species. Б-type is equally-grained granite with chainlike-aggregative distribution of subisometrical quartz grains, and these chains are surrounded by unidimensional aggregates and (or rarely) single crystals. В-type is – equally-grained granite with "palmate"-aggregative and separate distribution of isometrical quartz grains, and their unidimensional aggregates (often in 2-

6 grains) are distributed in the feldspar groundmass at the same distance from each other". It is important that granite`s macrophysiography in the sense of these petrographers is close to some extent to the crystals` space lattice: "… as if it is a structural formula of a granite where its "lattice points" are filled with crystal grains of main rock-forming minerals, …and granites of these types in the first approximation could be attributed to different polymorph specia with respect to each other. Granite typification based on their macrophysiography is adopted now by the Russian Geological Survey as one of the main principles of granitoid intrusions disjunction and state 1:50000 scale mapping.

For every polymineral rock (even very simple) one could not imagine single mineral grain for characterizing of a whole rock. In this case the true rock element (component) or subsystem of the "natural rock" object-system will be some minimal mineral grain aggregate or its "unit cell", and its propagation could give a whole rock.

V. I. Dragunov and Cherepanov were the first to propose such idea in 1971. In 1985 I. S. Delitsyn published a monograph dedicated to monomineral quartz rocks texture formation where Russian platform sedimentary sands, Ukrainian shield quartzite-like sandstones and South-Eastern Baikal quartzites were studied. He compares patterns of diagrams of the quartz grains optical orientation R in rocks thin sections, varying in size and based on 10, 25, 50, 100, 200 and 400 grains measurements. He proved that even at the stage of unconsolidated sands they contain some stable and statistically significant quartz grains aggregates with definite optical orientation visible only within the limits of 25-50 grains in thin section (or about 150 grains in 3D image). This orientation pattern becomes weak with increasing area of the investigated thin section. Unlike sands, quartzitic sandstones reveal stable optical orientation of quartz grains aggregates that did not disappear with increasing of the investigated thin section area (about 200 grains). The optical orientation pattern of quartzites did not disappear for all varying measurement amount (from 25 to 500 inclusive) and, in addition, in every section (that was not registered for sandstones). *The revealed aggregates of mutually oriented quartz grains in monomineral quartz rocks can obviously be attributed to as their so called "unit cells*". Furthermore, during these investigations *the lower dimensional limit of these "unit cells"* (print in italics by M. Povarennykh) was firstly discovered for the above mentioned monomineral quartz rocks. It is surprising that these conclusions I. S. Delitsyn has made only in 1990 as a result of our discussion of his monograph (Povarennykh, 1989) (or 5 years later than it was published).

Lately the regularity (ordering) in the distribution of grains in monomineral quartz rocks (quartz veins of different origin and artificial aggregates incubated at the quartz substrate) has been noticed by R. L. Brodskaya and Y. B. Marin, A. N. Nikitin and O. A. Sustavov.

In connection to the above mentioned, it becomes clear that if the minimal volume of the monomineral quartz rock "unit cell" contains about 150 grains for each polymineral rock it should be significantly larger (see below).

It is interesting to compare these conclusions with the results of the investigations of Acad. M. A. Sadovsky and his colleagues on granulometric analyses of peat, sand-gravel soil and explosion crushed rock debris accompanied by rock acoustic spectra observation. They have established rock *natural lumpiness* (blocking) – existence of "preferential" ("fixed") jointing dimensions formed while crushing. As for the rock level, these fixed dimensions were as follows: *3-5, 20-25 and 450-500* millimeters. It is interesting that this hierarchical scale is very close to the known from the Hindu Abkhidkharma naturphilosophy Encyclopedia.

As it was shown (Povarennykh, 1989), the primary element of the object-system – "rock as essentially natural mineral paragenesis" – one should consider not a mineral grain (even for the monomineral rock!) but some minimal by dimensions aggregate of mineral grains, or the so called "rock unit cell" (or *frustum* – lump in Latin, and the phenomenon is proposed to be called *frustumation*).

Among the tasks in rock structure-textural analysis the following were chosen: 1) visualization (revealing) of rock "unit cells" (*frustums*) with the help of different methods (parallel with the above mentioned explosion crushing, acoustic irradiation, etching by acids, observation in polarized light) – R-lights tomography, generation of the second harmonics in central symmetrical minerals under laser irradiation, foto-, R- and thermoluminescence, magnetic liquids and nematic liquid crystals orientation for ferro- and diamagnetic rocks, etc.; 2) determination of the main *frustum* characteristics with the help of image analyzing computer programs (dimensions, forms, mutual location of minerals within it and at the boundaries between *frustums*); 3) understanding of the physical reasons and mechanisms of *frustum* formation in different rocks (in addition to the possible triboelectrical for the above mentioned sedimentary quartz sands and magnetic forces for magnetite grains in carbonatites; 4) establishment of the rock space filling character (with the help of Nalivkin`s curvilinear symmetry or Mikheyev`s homology terms).

One can observe the first steps of the revealing and visualization of *frustums* during the macrophysiographical petrographical analysis of several rocks. *Frustumation* has been firstly revealed in several samples of the primarily chemogenic metamorphosed small-medium grained equally-grained translucent nonfractured Karrara (Toskana, Italy) *statuary* calcite-dolomite *marble* under the influence of short-wave (254 nm) ultra-violet emanation of mercury-quartz high-pressure lamp SVD-120 as a source of luminescence stimulation (Fig. 1), and then in numerous samples of several following rocks of different genesis: 1) small-medium grained equally-grained translucent nonfractured Kibik-Kordonsky (Krasnoyarsky district, Siberia, Russia) *statuary and facing calcite marble*; 2) primarily magmatogenic medium-grained nonequally-grained weakly translucent weakly fractured calcite barren *carbonatite* (Bol`shetagninskoye Nb-Ta deposit, Sayan, Russia); 3) primarily magmatogenic autometasomatically changed small-medium grained equally-grained nonfractured amazonite-albitic rare metal *subalkaline granite* (Aetykinskoye Ta-Nb deposit, Transbaikalia, Russia); 4) primarily magmatogenic autometasomatically changed course-grained up to pegmatoid equally-grained nonfractured amazonite-albitic rare metal *subalkaline granite* (Aetykinskoye Ta-Nb deposit, Transbaikalia, Russia); 5) metasomatic course-grained translucent fractured *datolitic skarn* (Dal`negorskoye deposit, Russian Far East); 6) primarily magmatogenic hydrothermally changed course-grained up to pegmatoid equally-grained fractured *silicate pegmatite nucleus* (Kalba deposit, Kazakhstan); 7) primarily magmatogenic autometasomatically changed small-medium grained equally-grained nonfractured rare metal *alkaline granite* (Zashikhinskoye Ta-Nb deposit, Eastern Siberia, Russia); 8) primarily chemogenic course-grained nonfractured *halite* (Verkhnekamskoye deposit, Perm`sky region and Nivenskoye deposit, Kalinigrad region, Russia); 9) primarily magmatogenic medium-grained equally-grained nonfractured *granite* (Korosten`sky massif, Ukraine); 10) primarily magmatogenic autometasomatically changed small-grained equally-grained nonfractured *liparite* (Tyrnyauz, Northern Caucasus, Russia) (Povarennykh, 2006; Povarennykh, Beskin, 2006).

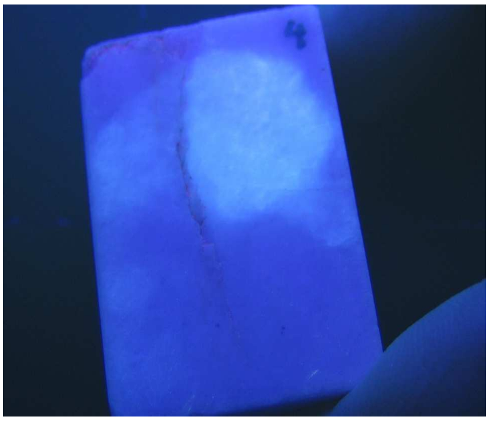

Fig. 1. Frustumation character within the Karrara (Toskana, Italy) calcite-dolomitic statuery marble revealed under UV-irradiation. Two types of frustums due to UV-luminescence of oxygen defect complexes: light-blue and dark-violet with the maximum about 490 nm wave length strip (Gotze et al., 1999); length of the sample short edge – 3 cm

Frustums observed in samples from the Karrara and Kibik-Kordonsky marbles, Bol`shetagninsky carbonatite and Aetykinsky rare metal granite of different types have been visualized by the bright-blue luminescence with a 490±15 nm band that may be attributed to oxygen defect complexes (after Gotze et al., 1999) [10]. The intensiveness of luminescence in the neighbouring *frustums* (dark-violet coloured) was 2-3 times smaller than those belonging to the visualized by bright-blue luminescence. *Frustum* in the Dal`negorsky datolite skarn has been visualized by bright-yellow luminescence colour interpreted as presence of (Eu^{2+} + Eu^{3+}) microconcentration instead of Ca^{2+} in its composition (two-humped band with 350 and 370 nm peaks).

Characteristic dimensions and outlines of the *frustums* within the investigated rocks vary greatly especially for mono- and polymineral rocks. The smallest *frustums* by the amount of mineral grains they contain have been observed in monomineral rocks: datolitic scarn, silicate quartz pegmatite nucleus, galite and statuary marble (about 125-300 grains in volume). The largest *frustums* have been observed in polymineral rocks: medium-grained amazonite-albitic and pegmatoid rare-metal granites (more than 5000-6000 grains in volume). *Frusumation* within the small-grained metasomatically changed granites of the Zashikhinskoye rare-metal deposit (Eastern Sayan, Russia) was observed in the form of the 3-5 cm in diameter subisometrical (in plane) mineral grain aggregates that may be interpreted as untwisting helices about 10 cm in height – analogues of the *Benard cells* oriented by the dissipation gradient (Prigogine et al., 1977-2002).

In order to reveal the petrophysical essence of the rock primary lumpiness (*frustumation*), it is planned to conduct a complex different scale investigations (from nano- to decimeter levels) of magmatic, metamorphic and sedimentary rocks with simple mineral composition and genesis with the help of traditional mineralogical-petrographical methods as well as neutronographic research methods of rock structure and strain analyses (SANS and neutron diffraction), rock thermal resistance determination method, laser-ultrasonic (see Fig. 2) and confocal spectroscopy, luminescence.

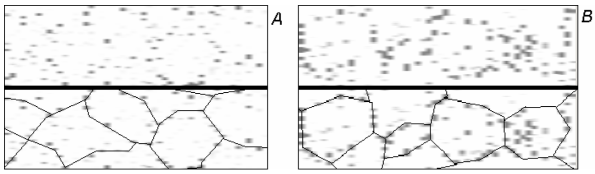

Fig. 2. Frustumation supertexture pattern of rocks inner composition vizualised with the help of laser ultrasonic echoscopy: A – medium-fine grained Kibik-Kordonsky calcite-dolomitic marble, B - medium-fine grained Kyshtymsky granulated quartzite. Specimen width: 13 and 12 mm, relatively. Upper part of picture – original pattern, lower – retouched

The morphology of *frustums* (rock "unit cells") in the investigated rocks looks very intricate, and it'll be possible to use fractal theory for its description. 3D rock body filling regularities and symmetrical tasks arise with the *frustumation* discovery are likely to be described by 11 possible Kepler-Shubnikov-Delone nets and 28 Andreini space partitioning.

As it is shown, the later subsequent processes (amazonitization, albitization, and quartzitization in granites as well as ore mineralization development in alkaline granite) inherited the *frustums* boundaries as weakened zones within these rocks and to some extent underlined it by their more abundant occurrence. Features of this firstly discovered macroscopic stereological rock phenomenon and its possible implications to conservation and preservation of rock-made artefacts as well as its effect on rock crushing and ore dressing are discussed (see Table 1).

Table 1

Correlation between the granulometric fraction composition of the Zashikhinsky granite and Bol`shetagninsky carbonatite after crushing up to "-100 mm" and "-50 mm" (respectively) and dominating dimensions of frustums (75-45 and 45-25 mm, respectively) within it

Fraction class, mm (Zashikha)	-100 +75	-75 +50	-50 +30	-30 +20	-20	Total
Yield, %%	0	59.9	29.8	7.0	6.3	100.0

Fraction class, mm (Bol`shetagna)	+50	-50 +25	-25	Total
Yield, %%	8.01	61.02	30.97	100.00

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